Photonic Science
Scientific Detector Systems

PSL Software Manual

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1. Install

1. Installing the software

Just copy the main application directory “*PSL_Software*” anywhere on your PC.

Important note:
If you try to install an **ImageStar9000**, please copy the “libpsl.dll” file in “C:\WINDOWS\System32” directory. This file can be found in the “DLL” directory of the software.

2. Import your correction files

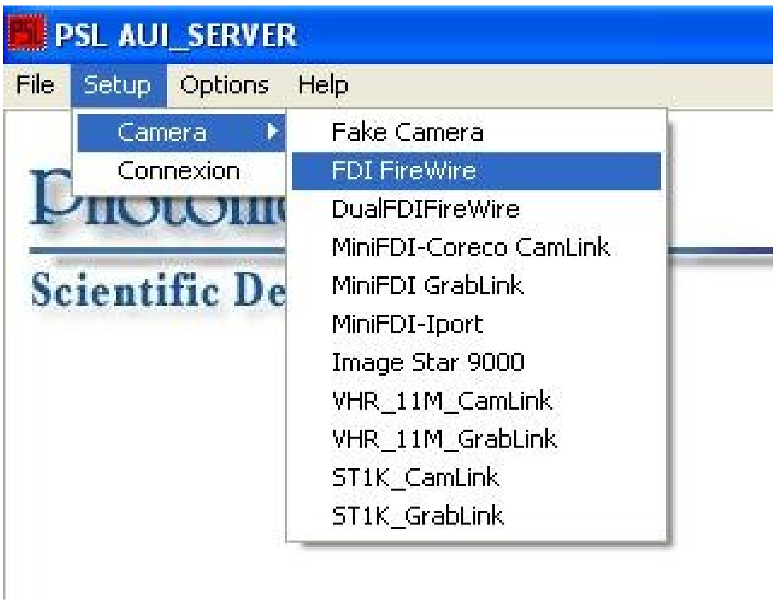
If you need to import correction files for your camera, look for a folder with the same name as your camera (in the main application directory) and open it.
Then, copy your files into the “PSL_camera_files” folder.
Ex: *“PSL_Software\FDI_FireWire\PSL_camera_files”*

3. Start the application

Open the main application folder *“PSL_Software”* then double click on *“AUI_Server.exe”*.

2. Select a camera

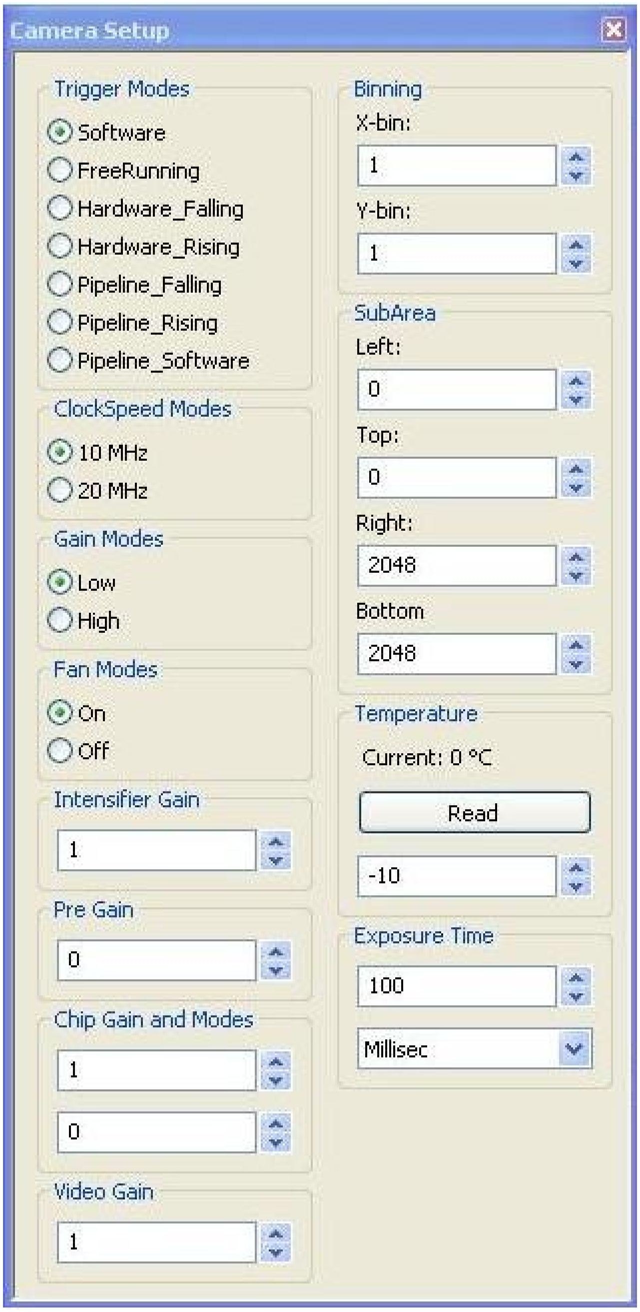
In the menu bar, select *“Setup”* => *“Camera”* then select your camera.



Once you have selected your camera, two control panels are generated, the *“Camera Setup”* panel and the *“Snap Setup”* panel. Each of them auto-detect all available options for your camera and remember the last configuration. Options that require specific correction files only appear if files are correctly loaded.

3. Camera setup

This panel allows you to set all camera hardware options.
The option [min:max] range is auto-detected for your camera and prevent bad settings. All options can be set during the acquisition process thanks to a multi-threaded software architecture. This case, modifications are done just before the next exposure. If no acquisition process is running, the modification is immediately applied to the camera. However, for camera stability it is better to do not change the *"Trigger Mode"* and *"SubArea"* options during the acquisition process. But feel free to play with others during a sequence acquisition to find your best settings real time.



Exposure Time

The integration or exposure period of the CCD is user-selectable via software over a very large range. The integration period is defined by a 14 bit number (range 1 to 16384) together with a unit (microseconds, milliseconds, or seconds). Very fine control of integration period is therefore available to the user.
Note that the driver written by Photonic Science always uses the finest unit available for any particular selected integration period, eg. an integration period of 17 seconds is transmitted to the camera as period = 17, unit = seconds, whereas an integration period of 16 seconds is transmitted to the camera as period = 16000, unit = milliseconds.

Video Gain

Video Gain is user selectable via the software driver in 100 steps. The transfer function is approximately logarithmic. Gain amplifies the signal amplitude but does not change the fundamental signal-to-noise ratio.
An additional "Gain boost" feature is available in the camera to achieve much higher amplification of the signal, but is disabled in the standard version of the camera to limit the noise amplification that inevitably also occurs when very high gain is applied. Please contact PSL if you would like to access this feature.

On-chip Binning

On-chip binning is the process of summing the signal from neighbouring pixels prior to the readout of this signal from the CCD. It has the effect of increasing the signal amplitude (by a factor equal to the number of pixels being binned), whilst making little change to the random noise amplitude. The signal-to-noise ratio of a signal therefore improves by the binning factor. Binning reduces resolution by the binning factor in both X and Y directions. Binning in the Y-direction also reduces the time taken to read out the CCD, very approximately by the Y-binning factor.
For example, when compared to a 1392 x 1040 unbinned image, an image captured with 3 (X) x 2 (Y) binning would have a resolution of 464 x 520, a signal amplitude six times higher, and would read out in about half the time.

Sub-area Operation

Only the image data for this rectangular sub-area being transferred to the PC. This feature can be used in conjunction with binning, to provide the user with considerable flexibility in image location, size, frame rate, and resolution.
The time taken to read out the CCD will be reduced, in proportion to the number of whole TV lines that are above and below the sub-area selected. For example, if the sub-area (200,200) - (700, 700) were selected, then readout would occur in about half the time of a full 1392 x 1040 image, and the image returned to the PC would have resolution 500 x 500. If in addition binning of 2 x 5 were selected, the sub-area selected would be unchanged but the image resolution would become 250 x 100.

Trigger Modes

The camera includes an external trigger feature that allows the camera's exposure to be synchronised with an external event. Two forms of this feature are available: a hardware trigger, and a software trigger. The hardware trigger input is an optional feature, whereas the software trigger facility is always present.
The camera has three software-selectable trigger modes:

Mode 0	Free running mode
Mode 1	Software triggered mode (default)
Mode 2	Hardware trigger mode, trigger on falling edge
Mode 6	Hardware trigger mode, trigger on rising edge
Mode 17	Software triggered pipelined mode
Mode 18	Hardware triggered pipelined mode, trigger on falling edge
Mode 22	Hardware triggered pipelined mode, trigger on rising edge

Mode 0: Free Running Mode

In this mode the camera is exposing and reading out continually, using the software-set integration period. The camera reads out one image while at the same time starting to integrate the next. Clicking the Snap button delivers an unsynchronised image, whose integration period may have started before the Snap button was pressed. The frame rate of the camera is dependent upon both the current readout settings (binning and sub-area settings) and the requested integration period. In preview mode with specific settings this can produce a higher frame rate, but in general we would recommend using software triggered mode rather than free running mode. For information on the settings to use to optimise frame rate in free running mode, please contact Photonic Science

Mode 1: Software Trigger

This is the default operating mode. The camera is triggered to grab an image and return it to the PC by a software-generated trigger. In this instance the unit is triggered via a command generated by the software running on the host PC. In most cases the camera will be triggered in this way by the user clicking on the Snap button.

Modes 2 and 6: Hardware Trigger

A 5V TTL hardware trigger input is available as an optional extra, specified at time of purchase: if fitted it will be in the form of a BNC connector on the rear of the camera body. On receipt of an appropriate trigger pulse on this BNC, the camera will integrate and read out an image using the current settings of integration time, binning, etc.

Mode 2: Trigger on falling edge

In this mode the falling edge of the 5V TTL trigger pulse starts acquisition of an image. The duration of the pulse is irrelevant. The integration period, binning, gain etc. are all set by the software.
Only one exposure per pulse is possible. If a second pulse is sent before the current triggered image has been read out it will be ignored.
Note that the camera will output an image only in response to the trigger pulse: it does not free run in between trigger pulses.

Mode 6: Trigger on rising edge

This mode is identical to mode 2, but the polarity of the trigger input is inverted.
If using the camera in hardware trigger mode, note that the “Snap” button has to be

clicked before the hardware trigger is sent. The procedure is thus:

1. Click on the Snap button. If the camera has been set into hardware trigger mode, this will not cause image acquisition: instead, the camera and framegrabber are prepared for the arrival of a hardware trigger.
2. Send the 5V TTL hardware trigger pulse to the camera. On receipt of this trigger, the camera starts to integrate at once, with the integration time and other settings .
3. After the image has been integrated, the camera reads out and returns its image to the PC.

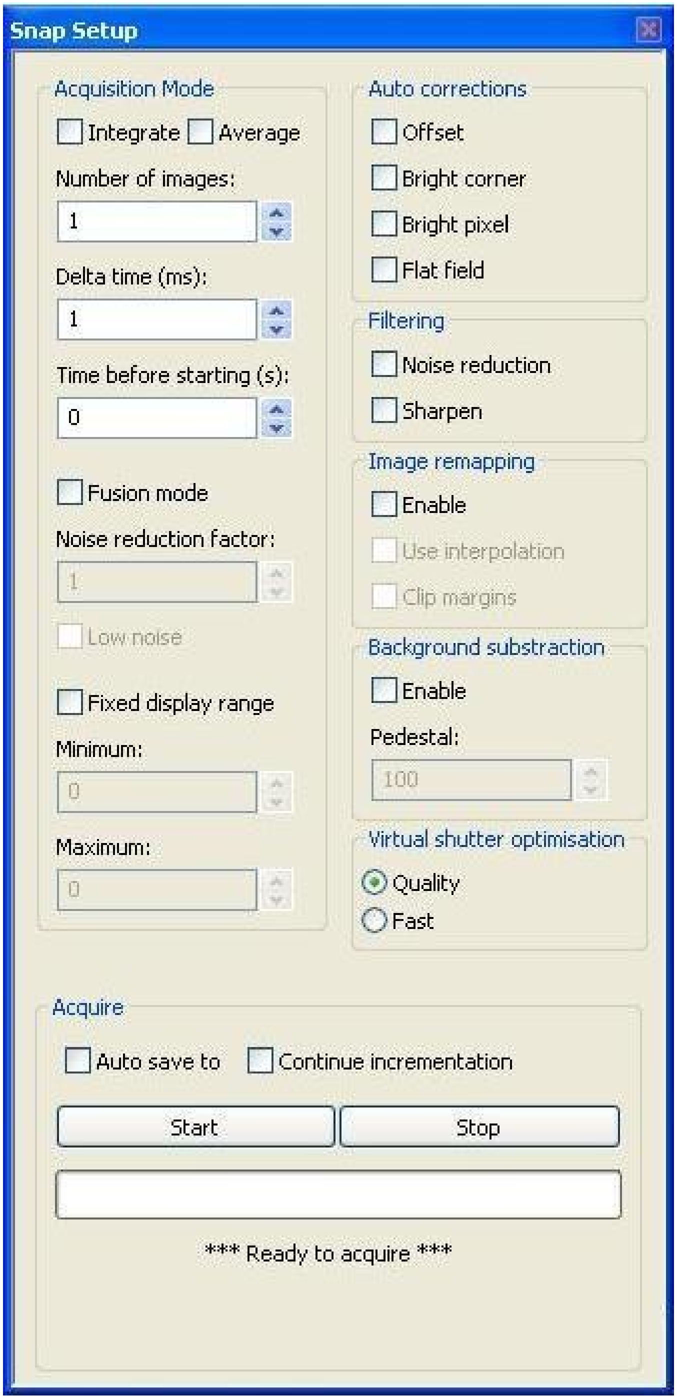
<u>Modes 17, 18 and 22: Pipelined modes, hardware and software triggered</u>

These modes are similar to the standard hardware and software triggered modes, but the CCD integrates an image while reading out the previous image. This results in higher frame rate when acquiring a repetitive sequence of a large number of images that all have identical integration time settings. These modes are unique in that they provide both triggered operation and the high frame rate usually only associated with the unsynchronised free running mode.
On receipt of an edge trigger on the input BNC or via the software, the camera will both begin integration of a new image (with the software-set integration period), and simultaneously begin readout of the previously-captured image. This gives the appearance of the camera returning an image as soon as the trigger is received, ie as if the integration period were very short. In practice, the image that is returned immediately after the trigger pulse is sent is the image that was initiated by the <u>previous</u> trigger pulse.
As each pipeline trigger returns the previous trigger's image, the first image of a pipeline sequence will be invalid and should be discarded.
The triggered pipelined modes can lead to higher frame rates and to the CCD exposing for a greater proportion of the time, compared to conventional triggered modes. The speed benefits are greatest when the integration period is slightly longer than the camera's readout time, for the particular binning/sub-area mode you are using.
The pipelined modes are designed for operation with integration period longer than the camera's readout period. However, integration times shorter than the camera's readout time are allowed, provided the <u>first</u> image acquired in the pipeline mode is with an integration period longer than readout. So, for example, if an integration period of 50ms is to be used in pipelined mode (which is shorter than readout in bin 1x1 full area mode), then first set the integration to 200ms (longer than readout), snap and discard one image, then switch to 50ms integration and commence acquisition.

The maximum frequency at which the camera can be triggered in the pipeline modes is dependent on the integration period chosen. If the integration period is longer than the readout period, the maximum trigger frequency is the reciprocal of the integration time (eg. 5 Hz with 200ms integration period selected). If the integration period is shorter than the readout period, the maximum trigger frequency depends on the integration time in a complex way, but is roughly equal to the reciprocal of the readout period. If you intend to use the pipeline modes and to operate the camera with short integration period and at the highest possible trigger frequencies, please contact Photonic Science for guidance.

4. Snap setup

This panel allows you to set the acquisition process and enable the corrections.
To start an acquisition, set the number of images you want to acquire then click on the *"Start"* button at the bottom of the panel. To abort the current acquisition process, click on the *"Stop"* button. During acquisition of a sequence of images, all of them are displayed in the same window. To save all the images of the sequence, click on the *"Auto save to"* check-button.
Thanks to a multi-threaded software architecture, you can modify all options or open/save file images during the acquisition of a sequence or a long exposure image.
To run the camera in a kind of preview mode, just set a large number of images.



Acquisition Mode

Integrate:
With this option enable, each new image is add to the sum of previous ones.
The resulting image data are converted to 32bits integer values.

Integrated_Image_N = Image_N + Image_N-1 + ... + Image_1

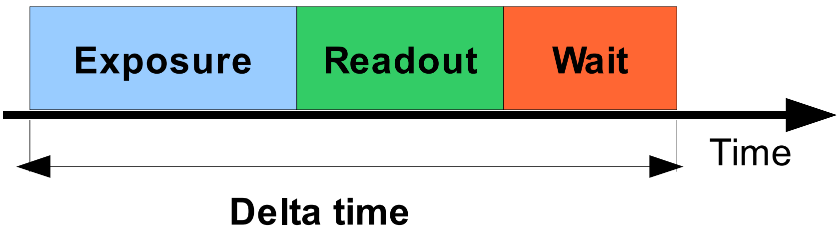
This way, for low signal acquisition, instead of acquiring one image with a long exposure, you can set a short exposure time and integrate the signal until the image intensity reach the required level. If the *"Offset"* or *"Background"* corrections are enabled, the integrated image is corrected from the *"Pedestal"* accumulation.

Average:
With this option enable, each new image is the average of all images of the sequence.
The resulting image data are converted to 32bits float values.

Average_Image_N = (Image_N + ... + Image_1) / N

This option is particularly convenient to flatten the noise when acquiring a background image.

Delta time (milliseconds):
With this parameter you can force the time between each images of a sequence to be constant. If you set a value inferior to {exposure time + readout time}, this option is non-effective. The readout time is the time taken by the camera to extract and process the data.

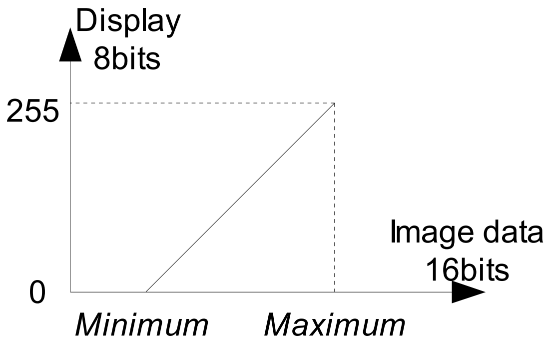


This option could be useful to synchronize a sequence acquisition with an external timed process.

Time before starting (seconds):
With this parameter you can specify to wait before starting an acquisition.
This could be useful to synchronize with the beginning of an external process.

Fusion mode:
This option extend the dynamic range of the camera by 16 times. A *"Noise reduction factor"* value of between 1 and 16 can be selected. A setting of 16 offers the least noise at higher grey levels but at the expense of increased overall acquisition time. A setting of 1 minimises acquisition time but has higher noise at the higher grey levels.
If available on your camera, you can also enable the ***"Low noise"*** option to reduce the noise.

Fixed display range:
For the display on screen (8bits), image data (16bits) are scaled on 255 grey values. If this option is not enabled, the scaling is done using the [min,max] pixel values in the image. If enable, the ***"Minimum"*** and ***"Maximum"*** parameters are used.



All pixels below the *"Minimum"* are set to 0 (black) and all pixels above the *"Maximum"* are set to 255 (white).
Just after the acquisition of an image, if this option is disabled, the *"Minimum"* and *"Maximum"* parameters are automatically set to the {min,max} values in the image.

Auto corrections
The driver provided by Photonic Science allows various image enhancements to be carried out automatically as an intrinsic part of the acquisition process. These enhancements include:

Offset:
Enable this correction to automatically carry out a "dark subtraction" as part of the acquisition process. To do this the driver loads a stored dark image of the appropriate binning setting and subtracts it from the acquired image before returning the image. This process sets the *"Pedestal"* (the average value of the image in darkness) to 100 ADU over the whole image in all binning modes. This correction supports binning and sub-area operations.
Note: offset correction can be enabled only if the files ***"darkbin*x*.flf"*** have been previously installed and loaded correctly during camera initialisation. Those files have to be in the *"PSL_camera_files"* folder corresponding to your camera (a range of such files are provided with the camera). If you would like to operate the camera with auto offset correction in a binning mode for which a stored dark file is currently unavailable, please contact Photonic Science.

Bright corner:
At long exposure times the dark current in this camera is spatially non-uniform, with a higher value along the top edge of the image. Bright edge subtraction removes this dark current together with its non-uniformity, thereby giving an image with practically zero dark current.
Note: bright corner correction can be enabled only if the file ***"brightcorner.flf"*** has been previously installed and loaded correctly during camera initialisation. This file has to be in the *"PSL_camera_files"* folder corresponding to your camera (such file is provided with the camera).

Bright pixel:
Enable this correction to reduce the number of bright pixels (individual high dark current pixels). The CCD sensor in this camera is cooled to reduce dark current. This cooling results in the dark current in the majority of pixels to be negligible, allowing very long on-chip exposures. There are however a small proportion of isolated individual pixels with higher dark current, which can appear as bright pixels at longer exposure times. *"Bright pixel"* automatically subtracts these bright pixels from the image as part of the acquisition process.

Flat field:
Wide aperture lenses and fibre-optics can introduce shading across an image, resulting in reduced intensity at the edges of the image compared to the centre and in small scale patterning from fibre optic structure. Flat field correction restores the intensity in the shaded areas and removes any patterning to compensate for such effects, and produces an image of very high spatial uniformity. When enabled, this function divides the acquired image by a stored flat field image, on a pixel-by-pixel basis, as part of the acquisition process. This correction supports binning, sub-area, and gain operations. For best results, always enable *"Offset"* correction when using flat field correction.
Note: flat field correction can be enabled only if the file "flat.flf" has been previously installed and loaded correctly during camera initialisation. This file has to be in the "PSL_camera_files" folder corresponding to your camera (such file is provided with the camera).

Image Remapping:
Enable this option to remove the effect of fibre-optic distortion by automatically resampling the raw image. Enable *"**Use interpolation**"* to use sub-pixel interpolation of the original image, which eliminates any aliasing effects introduced by the resampling. Enable *"**Clip margins**"* to exclude edge irregularities caused by the remapping process, and to present a cleaner remapped image, particularly when sub-area operation is employed.
Note: image remapping can be enabled only if the file *"**distortion.map**"* has been previously installed and loaded correctly during camera initialisation. This file has to be in the *"PSL_camera_files"* folder corresponding to your camera.

Background subtraction:
Enable this option to subtract a background image to each acquired image of a sequence acquisition. The ***"Pedestal"*** parameter is an offset add to the image before subtracting the background to avoid clipping of data below zero. The pedestal is the average value of the image in darkness.
Remember to use a remapped background image if you want to apply this correction to remapped images.

5. Open & Save files

To save or open a file image, click in the menu bar on the ***"File"*** menu then, click on ***"Open..."*** or ***"Save as..."***. Available formats are:

"TIFF", "JPEG", "BMP", "GIF", "PNG", "FLF", "ICO", "PNM", "PCX".

6. Creating correction files

The software allows you to create your own correction files. For example, you can acquire an image and save it as a background image and use it in the *"Background subtraction"* correction (see p.11).
To do this, you only have to save your image as "FLF" format and save it in the PSL_camera_file directory corresponding to your camera.
The correction file name must respect the convention show in the array below.

Correction	**Flat field**	**Bright corner**	**Background**	**Offset**
File name	*"flat.flf"*	*"brightcorner"*	*"background"*	*"darkbin*x**"*

Ex: *"PSL_Software\MyCamera\PSL_camera_files\background.flf"*.

When saving a new correction file, you need to reload the camera to apply the modification. To reload the camera, just select again your camera in the menu bar ("Setup" => "Camera" => MyCamera).
Note: for the ***"Offset"*** correction the file name depend of the binning mode and clock speed mode of the camera.
Ex: if binning is 2x3 and clock speed is 10 Mhz, the file must be called: *"darkbin2x310"*.

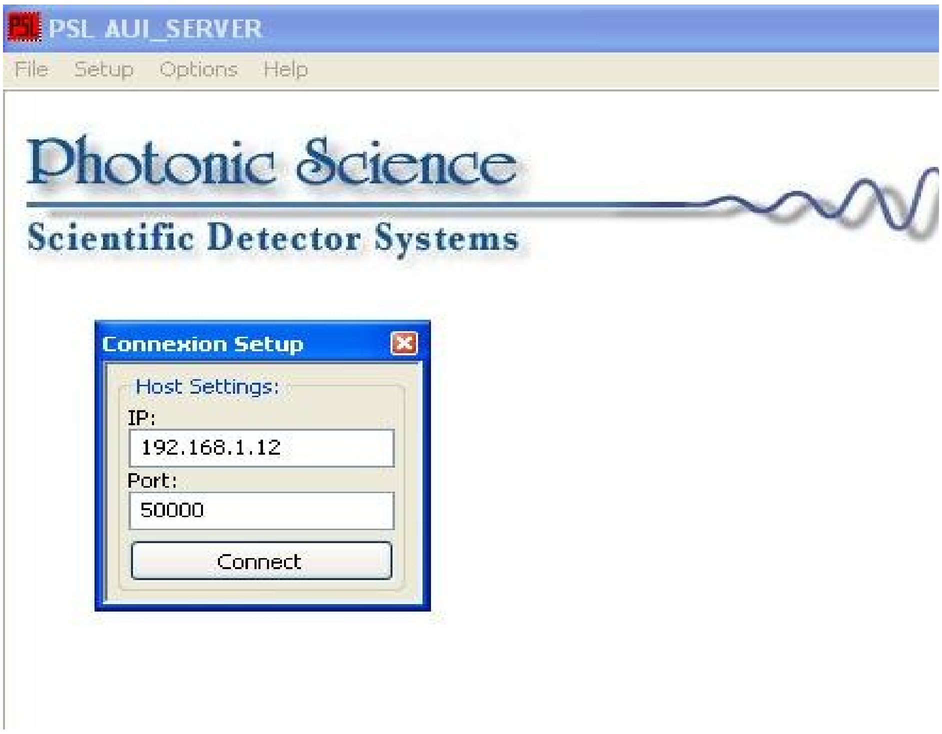
1. **<u>Create a *"Background"* correction file:</u>**
   The background image must be taken in exactly the same conditions as in your experimental conditions.
   - Disable the *"Background subtraction"* option in the *"Snap Setup"* panel
   - Turn the light source off and take an image or several images with the ***"Average"*** option enabled
   - Save this image.
   - Enable the *"Background subtraction"* option and select the image.

2. **<u>Create *"Offset"* correction files:</u>**
   For all x and y binning modes and clock speed modes (if available):
   - Turn all corrections off, fusion off
   - Capture at least 16 dark images with the ***"Average"*** option enabled
   - Save the image as "darkbin***Xbin***x***Ybin***.flf" in the "*PSL_camera_files*" directory corresponding to your camera

3. **<u>Create a *"Flat field"* correction file:</u>**
   - Set binning to 1x1
   - Turn ***"Offset"*** correction on
   - Capture a sequence of images with the ***"Average"*** option enabled
   - Remove an offset of 100 ADU to the image
   - Save the image as ***"flat.flf"*** in the "*PSL_camera_files*" directory corresponding to your camera

7. Use the camera as a device server

The software allows you to control the camera via the network with simple string commands.
To configure the server connexion, click in the menu bar on ***"Setup"*** then ***"Connexion"***.



To run the server, set the **IP** address of your computer and select a **Port** value. By default, keep the port 50000. If connexion failed try an other port or check the IP of your computer.
To get the IP number on windows, open the Command Prompt ("All Programs" => "Accessories" => "Command Prompt") then type ***"ipconfig"***.

To control the camera from the network you just have to connect your client to same IP and PORT as the server, then send the string commands.

Below, the list of commands that the server can handle:

'**Open**' => turn the camera on

'**Close**' => turn the camera off

'**Reset**' => turn off then turn on the camera

'**Snap**' => Capture an image

'**AbortSnap**' => Abort an image acquisition

'**Save**' => save the captured image at:
'*FileDirectory*'\ '*FilePreffix*'+'*FileRefNumber*'+'.'+'*FileFormat*'

'**CLIENT_CONNECTED**' => return: "!!!Welcome on PSL server!!!" (str)

'**GetImage**' => return: *((width,height), data)* ((int,int),str)

'**GetMode**' => return: image data type. Could be {'L', 'I;16', 'I', 'F'}.

'**GetExposure**' => return: *Exposure* (float) in milliseconds

'**GetBinning**' => return: (xbin,ybin) (int,int)

'**GetSubArea**' => return: (left,top,right,bottom) (int,int,int,int)

'**GetTriggerModes**' => return: *TriggerMode* (str)

'**GetFileDirectory**' => return: *FileDirectory* (str)

'**GetFilePreffix**' => return: *FilePreffix* (str)

'**GetFileSuffix**' => return: *FileSuffix* (str)

'**GetFileRefNumber**' => return: *FileRefNumber* (str)

'**GetFileFormat**' => return: *FileFormat* (str)

'**SetExposure**;1.33'

'**SetBinning**;2;2'

'**SetSubArea**;100;100;800;800'

'**SetTriggerModes**;Software'
trigger_modes = ['Software','FreeRunning','Hardware_Falling', 'Hardware_Rising','Pipeline_Falling','Pipeline_Rising','Pipeline_Software']

'**SetFileDirectory**;.'

'**SetFilePreffix**;pref'

'**SetFileSuffix**;suf'

'**SetFileRefNumber**;1234'

'**SetFileRWFlag**;True'

'**SetFileFormat**;tiff'

Note: for all “Set*” commands use “;” as separator.

Client example in Python:

```
import socket
import zlib

IP = “162.183.1.24”
PORT = 50000

def SendAndRecv(cmd):
        sock = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
        sock.connect((IP, PORT))
        sock.send(cmd+'\n')
        if cmd == "GetImage":
            nx,ny,data_len = sock.recv(1024).split(';')
            nx,ny,data_len = int(nx),int(ny),int(data_len)
            data = ""
            while 1:
                rep = sock.recv(data_len)
                data = "".join([data,rep])
                if len(data)>=data_len:
                    break

            data = ((nx,ny),zlib.decompress(data))

        else:
            data = sock.recv(1024)

        sock.close()
        return data
```